AQUATIC STUDIES

Title: **Interaction of Parasites for Cutthroat trout and Lake Trout in Yellowstone Lake, Yellowstone National Park**

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Objectives: Determine the parasites present in the two salmonid species in Yellowstone Lake, Yellowstone National Park, and the variation in parasite numbers. Determine if there are common parasites for the two salmonid species as well as those that are host specific. Do DNA analysis on the parasites. Correlate lake trout parasites for fishes from Yellowstone Lake and those in Heart and Lewis Lakes.

Findings: A total of 101 native Yellowstone cutthroat trout, *Oncorhynchus clarki bouvieris*, 27 introduced lake trout, *Salvelinus namaycushs*, and 40 introduced longnose sucker, *Catostomus catostomuss*, from Yellowstone Lake were examined for eye flukes in 1997. Metacercariae of a trematode fluke *Diplostomums* were in vitreous humor and/or lens of 94% of the Yellowstone cutthroat trout, 92% of the lake trout, and 78% of the longnose suckers. Longnose suckers had 7% prevalence of infections in both the lens and vitreous humor of metacercariae, while Yellowstone cutthroat trout had 3% and lake trout had 8%. *Diplostomum spathaceums* was in lens tissue of 5% of infected Yellowstone cutthroat trout and 93% of the longnose suckers, and *Diplostomum baeris* was in vitreous humor of 92% each of infected Yellowstone cutthroat trout and lake trout. Morphological characteristics indicate that a single species infected the lens of Yellowstone cutthroat trout and longnose sucker, while another species infected lake trout. Impacts of the parasite interchange between native and introduced fishes of Yellowstone Lake are unknown but should be monitored each year.

Title: **Reference Stream Monitoring - Long Term Trend Sites**

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Additional Investigators: Mr. Mark Rogaczewski

Objectives: Collection of long term monitoring data for water quality, macroinvertebrates, and habitat at least impacted reference stream sites in Yellowstone National Park.

Findings: Bioassessments at streams throughout Yellowstone National Park. Bioassessments include 12 water chemistry parameters, 13 habitat assessment parameters, and macroinvertebrates from eight modified surber samples. This data is available digitally from the principal investigator.

Title: **The Biogeochemistry of Sublacustrine Geothermal Vents in Yellowstone Lake, Wyoming**

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Objectives: Yellowstone Lake is an ecosystem in which closely linked components of microbiology, geochemistry, and mineral reactivity justify the term "Biogeochemical Cycling". The overall objective is to develop quantitative understanding leading to a biogeochemical flux and mass balance model for hydrothermal vent systems. More specific objectives are as follows:

A.) To determine the importance of vent and fumarole emanations relative to shallow groundwater and sediment-water flux in enrichment of major ions of Yellowstone Lake water; B.) To identify short (hours-days) and long-term (annual) variability in submarine vent activity; C.) To assess the potential geochemical interactions with iron during formation of iron oxides formed via vent fluid interactions with cold lake water; D.) To determine the relative importance of abiotic sulfur oxidation and microbially-mediated sulfur oxidation; E.) To determine the specific contributions of photosynthetic, heterotrophic, and chemolithotrophic biomass production; F.) To analyze transformations of sulfur by measuring the stable isotope composition of mineral, organic matter, and micro- and macroorganisms; G.) To utilize trace metal concentrations in aqueous and solid phases to evaluate hydrothermal activity and geochemical processes participating in elemental cycling; H.) To estimate the quantitative impact of sublacustrine hydrothermal vents and springs on the biogeochemical mass balance for the lake.

These efforts are intended to lead to a significant quantitative improvement in understanding of biogeochemical dynamics for select parameters. Control of nutrient and trace element cycling involves physical transport (e.g., riverine inflow and outflow, sediment-water flux, hydrothermal venting, groundwater inflow and outflow, mixing), chemical transformation (e.g., sorption by minerals precipitated from vent fluids, precipitation and dissolution, oxidation-reduction transformations), and biological interactions (e.g., assimilation into biomass, energy-yielding oxidation-reduction transformations, organic matter diagenesis). This work will provide background necessary to begin modeling basin-wide fluxes of biogeochemical important elements to elucidate the contribution of geothermally altered groundwaters to Yellowstone Lake.

Findings: Several interesting and unique sublacustrine hydrothermal areas were discovered, explored, and sampled in the following areas of the lake: at least three distinct regions in West Thumb, off Stevenson Island, in Mary Bay, in Sedge Bay, and off Storm Point. In addition, some relict hydrothermal features have been identified in Bridge Bay. Future plans include a precision bathymetric survey of the northern part of the lake to assist in the elucidation and discovery of other geothermally active regions of the bottom.

Title: **Heavy Metals in Soda Butte Creek**

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Objectives: This study: 1.) documents the distribution of trace metals in stream bed sediments of Soda Butte Creek at spatial scales ranging from 30 cm to 30 km and temporal scales ranging from 2 hours to 6 years; 2.) examines the processes causing variations in these distributions; and 3.) determines the links between trace metal concentrations and biotic health in the riparian zone.

Findings: Trace metal concentrations in the stream bed generally decrease in the downstream direction as a function of dilution mixing with clean sediments from tributaries. Local scale metal variations in riffles, pools, and bars vary as a function of sediment size and perhaps as a function of residence time and resultant accumulation of iron oxides. Biodiversity within the stream improves within the downstream direction, but has shown little improvement over the last 50 years. In contrast, some biotic impacts in the floodplain 20 km downstream are as severe as those at the tailing site. The amount of impacted area in the floodplain, however, is slowly improving over time as contaminated sediments are removed by floods.

Title: **Rainbow Trout Tolerance of Elevated Boron Concentrations in the Firehole River**

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Objectives: 1.) Review historical data related to the trout fishery, routine water quality parameters, and boron concentrations in the Firehole River. 2.) Sample Firehole River water in May, to analyze for routine water quality parameters and concentrations of boron.

Findings: We prepared a report (Meyer et al. 1996) about 1.) the history and current status of the rainbow trout fishery; and 2.) the historical database for water chemistry and physical habitat in the Firehole River (FHR) in Yellowstone National Park (YNP), Wyoming. In addition to conducting our own literature searches, we relied extensively on publications, reports, and data stored at YNP headquarters in Mammoth, Wyoming.

The rainbow trout (RBT) fishery in the FHR is unique, because the population effectively is closed to immigration by physical barriers on the downstream end (Firehole Falls and Cascades of the Firehole). Moreover, the population is contained within the relatively shallow-gradient stretch of the FHR along the Lower, Midway, and Upper Geyser Basins by a physical barrier upstream of the Upper Geyser Basin (Kepler Cascades). Due to thermal inputs from the geyser basins, this stretch of the FHR contains relatively warm and highly mineralized water.

Because RBT have not been stocked in the FHR since 1955, the population is self-sustaining. However, during summer large numbers of RBT migrate out of the mainstem FHR and into cooler-water tributaries, ostensibly because water in the FHR warms to potentially lethal temperatures (up to 30 degrees C).

Concentrations of boron (input mainly from geothermal sources in the geyser basins) also increase as flow in the FHR decreases during summer. Thus, avoidance of elevated boron concentrations (or a combination of boron and other dissolved constituents and temperature) cannot be rejected as an explanation for RBT migration out of the mainstem FHR. However, for the following two reasons we conclude that elevated boron concentrations alone cannot be responsible for the RBT migration in summer. First, limited historical data suggest boron concentrations in the FHR are even higher in fall and winter (when female RBT undergo oogenesis, adults spawn, and eggs are incubating in the gravel redds) than they are during the warm water period in summer. Second, our statistical analyses of historical water quality data indicated a high correlation between boron concentration and conductivity of the water (a parameter measured much more often than boron concentration). Using historical conductivities and flow measurments, we estimated that boron concentrations in the Lower Geyser Basin reach of the FHR likely are about 0.8 to 0.9 mg/l during the RBT egg maturation period in fall and about 0.9 to 1.0 mg/l during the spawning and embryo development periods in late fall and winter (compared to about 0.6 to 0.8 mg/l during summer).

Insufficient information is available to determine if successful recruitment of RBT occurs in those high boron concentrations in the mainstem FHR, or if the majority of the recruitment in the population comes from tributaries that have lower boron concentrations.

As part of this project, we also collected water samples from the FHR and several tributaries on May 15, 1996. Although we had hoped to analyze pre-runoff concentrations of boron, warm weather and rain beginning a few days before our sampling trip initiated high spring runoff. Thus, our chemical analyses are representative of dilute conditions, rather than highly concentrated late-winter conditions. We sampled water at the following five stations: 1.) FHR, about 250 m upstream from Grand Loop Road bridge (downstream from Kepler Cascades); 2.) Iron Spring Creek, about 1 km upstream from Little Firehole River; 3.) Little Firehole River, about 200 m upstream from confluence with Iron Spring Creek; 4.) Firehole River, about 200 m downstream from Biscuit Basin foot bridge; 5.) Nez Perce Creek, at Grand Loop Road bridge. Temperature, pH, conductivity, alkalinity, calcium, potassium, magnesium, sodium, chloride, sulfate, fluoride, and boron at those five sites are listed in Table A-11 in Meyer et al. (1996).

Title: **Sources of Phosphate in the Headwaters of the Snake and Heart Rivers**

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Objectives: Conduct trophic state water quality research on lakes.

Findings: Water was collected on September 9, 1998. One sample from the north shore of Shoshone Lake had chlorophyll-A of 1.1 mg/l, secchi depth of 4-5 m, total phosphorus 0.036 mg/l. One sample from near the outlet of Lewis Lake had chlorophyll-A of 1.3 mg/l, secchi depth of 4-5 m, total phosphorus 0.02 mg/l.

Title: **Study of the Effects of the 1988 Wildfire on Yellowstone Stream Ecosystems**

Principal Investigator: Dr. G. Minshall

See Ecology

Title: **Hydrogeomorphic Approach to the Assessment of Wetlands in Yellowstone National Park**

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Objectives: Collect data in six to ten depressional wetlands in Yellowstone National Park. This data will be added to an existing database from Ninepipes National Wildlife Refuge and the Bandy Ranch. We are collecting data in the park due to lack of human disturbance and the probability that the wetlands sampled will remain in an undisturbed condition for reference purposes.

Findings: We have completed 10 percent of the data collection planned. We plan to be able to complete data collection in July of 1999.

Title: **Yellowstone River Basin - National Water Quality Assessment (NAWQA)**

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Objectives: The overall goals of the NAWQA Program are to 1.) describe current water-quality conditions for a large part of the Nation's freshwater streams and aquifers; 2.) describe how water quality is changing over time; and 3.) improve our understanding of the primary natural and human factors affecting water quality.

Findings: Samples were collected at several sites for bed sediment and fish tissue analysis. The samples were sent to the USGS National Water Quality Laboratory for processing. They will be analyzed for trace elements and organics.

Title: **Effects of Depleted Amphibian Populations on the Community Ecology of Alpine Ponds**

Principal Investigator: Dr. Wendy Roberts

See Ecology

Title: **Diatoms in Yellowstone National Park**

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Objectives: 1.) Determine rate of evolution of diatom endemic to Yellowstone Lake. 2.) Determine modern climate, limnological, and landscape processes affecting modern diatom distribution. 3.) Use fossil records of major lakes to reconstruct ecosystem past.

Findings: 1.) *Stephanodiscus yellowstonesis* evolved in Yellowstone Lake in a thousand year period (ca. 11,500 ybp > 10,500 ybp) 2.) Main determinant of diatom distributions is winter precipitation. The system is N-limited in drought years; N-replete in wet.

Title: **Upper Henrys Fork Watershed Stream Habitat Assessment**

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Additional Investigators: Jim Gregory

Objectives: 1.) Collect physical, chemical, and biological data on stream habitat conditions. 2.) Determine presence/absence and relative abundance of native salmonids

Findings: Thirty-seven stream reaches in the upper Henrys Fork watershed were surveyed in 1997. These included reaches on Robinson, Little Robinson, Wyoming, and Rock creeks that lie at least partially in Yellowstone National Park. Most surveyed reaches were impacted very little by human activity. Study streams were generally characterized by volcanic geology, low gradient, and fine substrate. Aquatic invertebrates were abundant in most streams, and invertebrate diversity was high. Invertebrate communities in the Yellowstone Park streams were dominated by water beetles and midges. Brook and rainbow trout were found in most reaches surveyed. Brown trout occurred in Warm River and Robinson Creek. Yellowstone cutthroat trout were observed in Robinson and Wyoming creeks.

Cutthroat trout were not observed in Robinson Creek above a barrier falls in Yellowstone National Park where they had been observed in a 1983 survey. Cutthroat were not observed in Rock, Snow, Fish, and Little Robinson creeks, which contained cutthroat in 1983.

Title: **Effects of Geothermal Additions on the Biology and Distribution of Trout in the Firehole River, Yellowstone National Park.**

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Objectives: Determine the extent that trout in the Firehole River reside in areas of high mineral concentrations and how this affects their distribution, behavior, and reproduction. This will be accomplished by performing a detailed study of the water quality and the trout population in the middle segment of the Firehole River.

Findings: Population surveys showed an increase in fish densities in the lower Firehole River (FHR) and Fairy Creek (FC) sites as water temperatures decreased in the late fall. Spawning runs were identified in the main stem of the Firehole River (FHR) and tributaries from November 1997 through January 1998. Abundant spawning redds were located in the highly mineralized waters in the lower FHR and in FC. Results from the water quality surveys have shown that FC had the highest mineral concentrations among all sites sampled in the FHR drainage. Spawning and large aggregations of fish observed in FC and the lower FHR indicate that the thermal/productivity preference by fish may override an avoidance response to the high mineral concentrations. Concentrations of arsenic (As) in FC and the lower FHR during 1997 were consistently observed above 350 ppb, exceeding the EPA Quality Criteria for Water (1987).

Analyses of chemical and fish distribution data are currently being conducted. A final report on the project should be completed during 1999, with publications expected in Transaction of the American Fisheries Society and/or the Archives of Environmental Toxicology and Contaminants. Locations of spawning in the Firehole River are being mapped using GIS and will be made available to the National Park Service when complete.